Canadian space research program

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THE CANADIAN SPACE RESEARCH PROGRAM

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Science and Technology Division
Research Branch
Ottawa

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INTRODUCTION

Canada has a long history in the area of space research. As long ago as 1882, during the first International Polar Year, space research was being carried out in Canada. More recently, Canada was the third nation to develop and orbit its own satellite (1962) and the first nation to operate a geostationary domestic communications satellite (1973). In 1981, our space expertise was again demonstrated with the successful testing aboard the United States space shuttle of the remote manipulator system better known as the Canadarm. Canada has also taken an international lead in the development and use of communications and earth resources satellite systems.

Space technology is at the leading edge of the high technologies currently pursued internationally. It is important in stimulating innovation, contributing to the overall advancement of science and providing valuable economic and technological spinoffs. An improved international stature is a further significant benefit derived from pursuing space research.

As the scale and sophistication of space research is constantly increasing, international collaboration on projects is becoming more commonplace. At present, most government agencies, including those in Canada, are seeking to more clearly define their basic space research goals and to attain these goals at a reasonable cost.

This paper reviews the history of Canada's space research program. Ongoing and potential future space activities are also discussed in the context of Canada's contributions to international space research, the Canadian space industry and the benefits derived from space research.

HISTORY OF CANADIAN SPACE RESEARCH

Activities associated with the Canadian space research program can generally be broken down into four interrelated areas:

(1) Space Science: Includes studies of such basic subjects as the earth's ozone layer, cosmic rays, the sun and meteors. Also includes development of methods and equipment (such as instruments, satellites, the Canadarm, etc.) for space research.

(2) Satellite Communications: Includes the development of the technological and commercial aspects of a global satellite communications capability. This includes both the space components (satellites and their associated hardware) and the ground-based components (e.g., earth receiving stations).

(3) Remote Sensing: Includes the application of science and technology to the reception, processing and use of signals received from aircraft platforms or foreign satellites. These signals permit such activities as resource management, environmental monitoring and satellite-aided search-and-rescue equipment.

(4) Satellite-Aided Navigation: Includes navigation aids for naval and coast guard operations and studies to improve safety and accuracy in air and sea navigation.

Over the past two decades, many significant advances have been made in Canada in these areas. The most important of these advances cannot be overemphasized:

- with the launching of the Alouette satellite in 1962, Canada became the third nation to enter space;
- the ANIK-A satellite launched in 1973 enabled Canada to operate the world's first domestic satellite communications system using a geostationary satellite orbit and fixed earth monitoring stations;

- in a joint effort with the U.S., the Hermes communication technology satellite was launched in 1976 and provided researchers with then the most powerful satellite available for communications experiments;
- the Canadian-designed and built remote manipulator system used on the U.S. space shuttle was successfully tested in space in 1981;(1) and
- SPAR Aerospace of Toronto has achieved prime contractor status following the awarding of contracts for Canada's ANIK-D and Brazil's Brazilsat satellite projects.

Based at least in part on these advances, as well as numerous others, Canada has established both a healthy national space industry to meet domestic needs, and a solid international reputation in space science and technology.

The development of the space research program and its associated resource and industrial base are elements of a national space policy which has been evolving since 1963.

In that year, the Federal Government first declared its objective of developing space technology in Canadian industry, rather than completely relying on foreign suppliers. Later, in 1969, the Interdepartmental Committee on Space (ICS) was established to review and coordinate Canadian space activities and resources, and to consider plans and policy. Representatives from over a dozen federal departments sit on the ICS, as shown in Table 1.

A "Canadian Policy for Space" was adopted in 1974, stating, among other things, that:

- a deliberate policy of moving government space research into industry should be followed to bolster Canadian industrial capability;
- Canada will continue to rely on foreign launch services and should enhance access to these services by participating in the supplying nation's space program; and

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(1) For a more detailed discussion of all aspects of the Canadarm, see, for example, J.F. Follwell and L.C. Myers, The Space Arm, Background Paper, Research Branch, Library of Parliament, Ottawa, 17 March 1982, 24 p.

TABLE 1: COMPOSITION OF THE INTERDEPARTMENTAL COMMITTTEE ON SPACE

Departments of: Communications
Energy, Mines and Resources
Environment
External Affairs
Fisheries and Oceans
Industry, Trade and Commerce
Transport

Ministry of State for Science and Technology

National Research Council of Canada

Ministry of State for Economic Development*

Privy Council Office*

Department of Supply and Services*

Treasury Board Secretariat*

* observer status only

- Canada's activities in space should contribute directly to national goals.

An earlier goal of supporting the development of a Canadian prime contractor for satellites was consistently pursued in the 1970s. As a result, SPAR Aerospace has achieved such a status for both domestic and foreign programs.

In 1981, the second three-year plan covering the period 1982/83 to 1984/85 was approved. The plan continued the development of the priority areas outlined in the first three-year plan, namely continued exploration of SPAR Aerospace as a prime contractor for satellites, strengthened international relationships in space and technology development. An additional $132 million was allocated for new initiatives, bringing the government's expenditures to $476 million over the four-year period 1981/82 to 1984/85.(1)

With government encouragement, the space industry has grown steadily since 1969. Over the same period, exports have increased and the industry has become less reliant on government expenditures. Significant economic and industrial benefits have accrued -- jobs have been created, imports replaced by exports and technological spinoffs have evolved. In 1982, industry sales were some $182 million, with about $113 million of this amount for export sales. Employment in 1982 was about 2,300 person-years.(2)

CURRENT CANADIAN SPACE RESEARCH

Although a complete enumeration of all ongoing Canadian space research projects would be too extensive to include here, the most important projects in each of the four main research areas are discussed below. The Canadian space industry is also reviewed.

A. Space Science

Space Science is perhaps the program most visible and interesting to the general public. In particular, Canada's exploits in the U.S. space shuttle program have gained widespread publicity.

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(1) Canada, Ministry of State for Science and Technology, The Canadian Space Program Plan for 1982/83 - 1984/85, Background Paper No. 20, Ottawa, 1981, p. 1.

(2) B. MacDonald, ed., Canada's Strategies for Space, The Canadian Institute of Strategic Studies, Toronto, 1983, p. 69-70.

Even though the bulk of the development of the Canadarm has been completed, work is ongoing to improve the arm's capabilities. Notably, a Space Vision System (SVS) is under development. The SVS utilizes a computer to enable precise positioning of the arm with respect to its target. Currently, such positioning must be done visually. Initial data were collected during the October 1984 shuttle flight, and will be used in subsequent design of the SVS.

Among the other experiments undertaken by Marc Garneau, Canada's first astronaut, during that flight were:

- an experiment to determine how sunlight is scattered or blocked in the earth's atmosphere by dust, pollution or moisture;
- an investigation of the mysterious glow sometimes seen around the shuttle in orbit, since this glow may pose problems for optical instruments;
- a materials-testing experiment to determine how well materials can endure the harsh space environment; and
- an experiment to measure the effects of space on man. Canada is second in the study of space sickness only to the U.S.

In connection with the space shuttle, the National Research Council (NRC) is maintaining the Canadian Astronaut Program. Six astronauts have been selected and are undergoing training as payload specialists. The program is expected to cost $4.5 million over three years.

Other important basic space science research has been carried out in some perhaps less familiar areas. For instance, in 1983, joint NRC-American teams of astronomers made two significant discoveries. In December 1983, studies of the energy emitted by distant galaxies have since forced scientists to reassess their concepts of galaxies. In June 1983, another team found what is believed to be the third black hole ever discovered in space, just eight months after the same team found the second. The first black hole was found some 12 years ago by a University of Toronto team.

These space science research projects, as well as numerous others, are important in advancing mankind's understanding and exploration of space, as well as promoting Canada's reputation and standing in the field.

B. Satellite Communications

The Department of Communications is participating in the 11-country European Space Agency's (ESA) OLYMPUS Satellite program, formerly called the L-SAT program. This program seeks to develop a large communications satellite, scheduled for launch in 1987. Two Canadian companies are involved in its manufacture, and the Department's David Florida Laboratory will be used in the environmental testing of the spacecraft. The total cost to Canada of the program until 1990 will be some $90 million.

It is hoped that the OLYMPUS satellite can be employed to explore the use of higher frequency signals on communications satellites, particularly since the lower frequency bands currently in use will experience a shortage of capacity by the end of the 1990's.

Other major programs include:

- the mobile satellite project (MSAT) to provide mobile radio and radiotelephone service to users in rural and remote areas; and
- a program investigating low-rate data and voice communications by satellite for trans-oceanic aircraft. Interest in this program is mainly for air-traffic control purposes.

C. Remote Sensing

Two major remote sensing projects are underway at the Canada Centre for Remote Sensing (CCRS), a branch of the Department of Energy, Mines and Resources.

CCRS participated in the ESA's Earth Resources Satellite (ERS-1) Program, which was in the predesign and preconstruction phases in 1983. The ERS-1 will be launched in April 1989 and will carry a range of

microwave sensors for ice, ocean and weather applications research. Canadian industry is participating in program and technology development contracts for the ground system and space telemetry elements of the project. Canada will invest a total of about $40 million in the $700 million project.

CCRS is also planning for a Canadian remote-sensing satellite, RADARSAT, and has completed mission requirements, conceptual design studies and an economic assessment. RADARSAT could be launched by 1990. International agreements have been reached with the United States and the United Kingdom for collaboration in the project. CCRS is developing critical radar technology for the space and ground systems, and has conducted aircraft experiments to simulate satellite performance over ice, icebergs and land.

D. Satellite-Aided Navigation

Canadian government vessels use satellite navigation aids in naval and coast guard operations, oceanographic research, fisheries patrol and management, and hydrographic surveys. To improve safety and accuracy in air and sea navigation, studies of possible uses of satellite systems such as the AEROSAT project and the United States NAVSTAR/GPS are in progress. Such systems could permit users to determine their position to an accuracy of better than 10 metres and could be operational by 1988.

In a related area, an international experimental project called SARSAT (for Satellite-Aided Search and Rescue) began in 1982. Canada, France, the United States and the Soviet Union are participating. It is hoped that a fully operational future system under international auspices can be established. Under the SARSAT agreement, Canada has supplied radio repeaters built by SPAR Aerospace for installation on three American weather satellites.

E. The Canadian Space Industry

As discussed earlier, in 1982 industry sales were $182 million. Canadian content was about 80% and 62% of these sales were for the export market.

Employment in 1982 was about 2,300 person-years, with SPAR Aerospace as the prime contractor accounting for about 60% of the industry's direct employment. There are over 50 companies involved in the industry. The main companies and their interests are shown in Table 2.

Although exact figures are not yet available, the level of employment and industry sales have grown steadily since 1982 and are expected to continue growing.

The outlook for the Canadian space industry is discussed below.

OUTLOOK FOR CANADIAN SPACE RESEARCH

Given the relatively fast pace in international and domestic space research projects, it is difficult to predict the course of space research developments much more than about five years into the future.

Certainly, many of the ongoing programs will continue into the late 1980's. These include the MSAT, OLYMPUS and ERS-1 projects. Since Canada is at present increasing its collaboration with the ESA, further joint ventures may be undertaken, such as an ERS-2 program, or participation in an independent ESA manned space program, should such a program move beyond the discussion stage.

One of the more ambitious projects would be for Canada to participate in the $8 billion U.S. manned space station to be launched by 1992. The ESA has already agreed to contribute $2.4 billion and Japan $1 billion to the project. A Canadian decision to join the project must be announced prior to April 1985 if we are to be guaranteed a place. Canadian contributions would amount to perhaps several hundreds of millions of dollars over the project life. Given the present fiscal restraint, it may be difficult to find the money, particularly without cutting back other research programs.

Any such Canadian contributions to the space station would seek to build on our existing expertise, including solar arrays to supply station electricity, remote-sensing equipment and a remote manipulator system (much like the Canadarm) for various station functions.

TABLE 2: PRINCIPAL CANADIAN SPACE COMPANIES

Company	Interests
Andrew Antenna Company Ltd	- antennas, transmission lines and related equipment
Boeing of Canada Ltd.	- structural and waveguide composite materials
Bristol Aerospace Ltd.	- instrument payloads; satellite and ground-based data systems
CAE Electronics Ltd.	- real-time computer-based systems including Canadarm display and control equipment
Canadian Astronautics Ltd.	- electronic, computer, microwave and mechanical products
Canadian Marconi Company	- electronic equipment for telecommunications, radar, ground and air navigation
Com Dev Ltd.	- satellite communications; microwave subsystems
DSMA Atcon Ltd.	- system engineering and design services
Fleet Industries	- specialized satellite structures
MacDonald, Dettwiler & Associates Ltd.	- ground stations and equipment for receiving and processing satellite sensing data
Miller Communications Systems Ltd.	- satellite communications systems engineering
Northern Telecom	- telecommunications research and development
Raytheon Canada Ltd.	- satellite communications earth stations
SED Systems Inc.	- ground terminals; earth stations; test facilities
Spar Aerospace Ltd.	- complete satellite systems (prime contractor); Canadarm manufacturer
Teleglobe Canada	- provides Canadian public with international telecommunications services
Telesat Canada	- operates Canadian domestic satellite communications system
TIW Systems Ltd.	- satellite tracking systems

Sources: (1) B. MacDonald, ed., Canada's Strategies for Space, The Canadian Institute of Strategic Studies, Toronto, 1983, p. 70.

(2) Canada, Ministry of State for Science and Technology, Canada in Space, Ottawa, 1982, p. 54-94.

The market for the space industry is somewhat easier to predict. According to one such forecast,(1) for the period 1983-1992 the planned Canadian expenditures on space technology are $1.35 billion. By comparison, the U.S. National Aeronautics and Space Administration is committed to about $53 billion over the same period and the U.S. Department of Defence to $80 billion. The total for Europe is about $16 billion and $3 billion in Japan.

These figures include a total international market for some 155 satellites of value $9.3 billion (in 1982 U.S. dollars), a military market of $2.3 billion and a remote-sensing market of $4.5 billion. In 1982, the Canadian industry captured 8.3% of the international market.

At this current market share, Canadian industry could thus expect an average annual market of $130 million (U.S.) during the period 1983-1992. This market growth would provide 50 to 60% growth in revenues, or even more if Canada's market share can be increased.

Capturing a large share of this market ensures not only economic benefits, but also a means of maintaining Canadian space research and the space industry at the leading edge of technology.

SUMMARY

Canada has developed expertise in all areas of space research - space science, satellite communications, remote sensing and satellite-aided navigation.

Many benefits have been realized through this research, including economic, industrial and scientific advances. For example, our communications system has given equal access to all Canadians to television, data and other systems. A focus has also been provided in universities and industry for further development.

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(1) MacDonald, B., ed., Canada's Strategies for Space, The Canadian Institute of Strategic Studies, Toronto, 1983, p. 71-72.

Through vigorously pursuing a space research program, Canada has increased its ability to control the sovereignty of our coastal waters and Arctic islands. Major steps have been made in improving surveillance and control of our resources through satellites. Canada has reduced its dependency on foreign-supplied operational systems, reduced its technical dependence on foreign industry, and reduced the vulnerability of its commercial developments to foreign priorities.

These benefits will continue to accrue as further space research efforts are undertaken.

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(2) Canada, Department of Communications, The Canadian Space Program; Five-Year Plan (80/81 - 84/85), Ottawa, 1980, 67 p.

(3) Canada, Department of Energy, Mines and Resources - Annual Report 1983/84, Ottawa, 1984, 23 p.

(4) "Canada in Space", Aerospace Canada, Vol. 6, No. 1, Winter 1982, p. 11 ff.

(5) Canada, Ministry of State for Science and Technology, Canada in Space, Ottawa, 1982, 94 p.

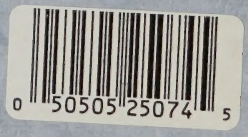
(6) Canada, Ministry of State for Science and Technology, The Canadian Space Program Plan for 1982/83 - 1984/85, Background Paper No. 20, Ottawa, 1981.

(7) Canada, National Research Council, The Canada Centre for Space Science, Ottawa, 1982, 48 p.

(8) Follwell, J.F. and L.C. Myers, The Space Arm, Background Paper, Research Branch, Library of Parliament, Ottawa, 17 March 1982, 24 p.

(9) MacDonald, B., ed., Canada's Strategies for Space, The Canadian Institute of Strategic Studies, Toronto, 1983, 120 p.

(10) "Ottawa Ponders Space Venture", The Globe and Mail, 30 January 1985.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